have been, and are now, supplying electricity by overhead wires without statutory powers, and being convinced of the undesirability of allowing this to be continued, would venture to suggest that, in any further legislation on electric lighting, the supply of electricity in any district, before obtaining statutory powers for such district, should be prohibited under penalty."

To this we see no objection, now that the Electric Lighting Act is so modified that it is possible for an electric lighting company to reap commercial success by working under it.

THE LIFE-HISTORY OF A MARINE FOOD-FISH.[1]

II.

THE larval salmon enters the world of a size—though small—that is readily recognizable, viz. about three-fourths of an inch in length, but the marine forms under consideration, from their minute size and glassy translucency, are almost invisible to the naked eye—just a gleam of light broken by the passage of a different medium, or a tinge of pigment, arresting attention. Only in the cat-fish (which is not much—though it ought to be more—of a food-fish) with its large egg, have we a size nearly reaching that of the salmon at birth.

We had left the larval fish tossed about by the currents and unable to struggle against them, now floating with its yolk-sac uppermost, or hanging in the water with its head downward, and again making spasmodic darts hither and thither. Soon, however, it gathers strength, and at the end of a week or ten days it glides actively through the water, and avoids both obstacles and enemies, the young cod nimbly escaping the forceps, poising itself in the water with its large pectoral fins (Fig. 11), and evincing both intelligence and dexterity. Moreover, this activity greatly promotes respiration in those like the gunard with a motionless mandible, the water being thus sent through the mouth and over the branchial region. Its mouth has now opened and the yolk-sac has been absorbed, while it feeds on the most minute of the little Copepods, especially those almost microscopic in size, that swarm in the surrounding water. The provision whereby such tiny fishes find in the ocean food suited to their capacities is one of the most striking features in Nature, but it has only recently been carefully investigated. It is a notion no longer tenable that during the winter and spring the sea, to a large extent, is devoid of the wealth of pelagic life so characteristic of the summer months—just as it is of the genial waters of the tropics. For several years, however, it has been found that a vast abundance of minute life of all kinds is present throughout the entire year—and from the surface to the bottom. Moreover, during the warmer months a constant succession of young forms rises from the eggs both of the sedentary and creeping animals on the bottom to the surface, where they sport in the summer sun, undergo certain changes, and again descend as they assume the form of the adult. The pelagic young food-fishes—swimming freely in the ocean—thus have a double chance at them; first in their very early stage as they rise, and again in their larger and later condition as they descend. The enormous numbers, countless variety, and ever-changing nature of the small animals either directly or indirectly constituting the food of these little fishes form an important feature in the economy of the sea. Such animal forms comprise those long known in the British seas, besides others more familiar to Arctic voyagers, or to the sunny waters of the Mediterranean, for, with modern apparatus and persistent efforts (thanks to the enlightened views of the Government acting through the Fishery Board), our knowledge is always extending.

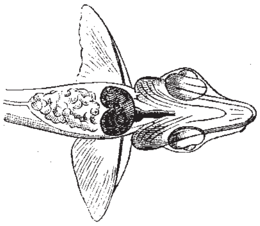

FIG. 11.—Ventral view of the anterior region of larval cod (magnified).

It is a remarkable fact that it is primarily to plants in inshore waters that the abundance and variety of animals are in many respects due, especially if estuaries also debouch in the neighbourhood. Thus nowhere are the swarms of Sagittæ, Appendicularians, Crustaceans, and other forms of fish-food more conspicuous than in the midst of a sea teeming with Diatoms, Rhizosoleniæ, and other Algoid structures.[1] These nourish many of the lower forms upon which the Crustaceans and other higher types feed, the latter again falling a prey to the fishes. Moreover, while the larger forms of the Copepods and other Crustaceans, for example, afford suitable nourishment for the more advanced post-larval fishes, the multitudes of larval Crustaceans (*Nauplii*) are adapted to the needs of the smallest larval food-fishes. Now this plant-life is specially abundant in April and May, just when the larval and very young post-larval fishes appear more abundantly in the inshore waters, so that the cycle is nearly complete, viz. from the inorganic medium through microscopic plant and larval Crustacean to the post-larval fish. I have mentioned the neighourhood of an estuary as a prolific source of food for young fishes, and I need only explain further by instancing the case of mussel-beds, which for months pour countless myriads of larval mussels into the adjoining sea, far beyond the needs of the area as regards mussel-culture, but which form a favourite food of the little 'fishes at all stages, but especially from an inch and a half to three inches in length. These fishes feed on the young mussels as they settle down on the sea-weeds, rocks, and zoophytes in August, after a free-swimming larval existence. Like some of the forms indicated above, mussels live to a considerable extent on microscopic plants and various minute organisms contained in the mud of the estuaries and other sites, so that a rich and favourite food, universally liked by fishes, is the product of these uninviting flats. Moreover, in passing, it may be remarked that, while everywhere preyed on by the food-fishes, it occasionally happens that in turn the mussel proves a source of inconvenience to them, for, settling on the gill-arches of haddocks, the mussels flourish on a site so suitable for aëration and food that they by and by press out the gill-cover and impede respiration, just as the shore-crab (which is also fond of mussels) has its eye-stalks wrenched out by the slow but sure growth of the young mussels which have fixed themselves in their sockets. Nemesis thus, by a chance of anchorage, converts a favourite food into a permanent inconvenience.

Again, in connection with the pelagic food of fishes, it is a well-known fact that adult cod are extremely fond of sea-anemones,[2] and some of the rarest species may be procured in their stomachs, a feature by no means surprising when we remember that Abbé Dicquemare cooked and ate his sea-anemones with great relish, and wrote in their favour, as also did Mr. Gosse in our own country. Now, the pelagic young fishes, instead of roaming near the bottom in proximity to the anemones fixed on the rocks, and running the risk of being themselves captured for food, find in the inshore waters in summer the larval *Peachiæ* in great numbers conveniently attached by the mouth to the little Hydromedusæ (*Thaumantias hemisphærica* and *T. melanops*) which occur in swarms in mid-water. Moreover, the somewhat larger young food-fishes (2 to 3 inches) show the same liking for the Cœlenterate group, by browsing on the zoophytes (*Obelia geniculata*) which cover the stones and rocks with feathery tufts, yet the zoophytes are not much the worse for this treatment, for they by and by shoot afresh, and clothe the area once more with dense forests. The rapidity with which such zoophytes grow is remarkable, though we must remember that in some cases the old stock naturally dies off after having produced swarms of pelagic young.

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[1] A Discourse delivered by Prof. W. C. McIntosh, F.R.S., at the Royal Institution, on Friday, February 1, 1889.

[1] The fact that certain fishes feed on Infusoria has not been overlooked.

[2] A favourite bait for cod in some parts; and from the fact, amongst others, that star-fishes do not molest them on the hooks, no bait is more successful.

Under this rich food, the young fishes grow apace; head and eyes, mouth and accessory organs, body and fins—all rapidly increase; and the little fish, hatched in the spring, say from March to May, is soon in what is known as the post-larval stage—that is, has lost its yolk-sac, has assumed a more or less uniform tint, and has gill-fringes and teeth. It is about a quarter of an inch long, and is both active and intelligent, the large head and large eyes of the young food-fishes being at this stage specially conspicuous, and in marked contrast with such as *Cottus*. The marginal fin is quite continuous at a quarter of an inch, and the lancet-like termination of the caudal end of the body is noteworthy.

About this time the ventral fins of the young fishes first make their appearance, for hitherto they have managed to do without them. Moreover, these fins in some, such as the rockling and ling, undergo remarkable development, forming in the latter (Fig. 7) a pair of great ventral wings, conspicuously coloured yellow; yet in the adult (a ground-fish) they attain no greater dimensions than in the cod, both having at a certain stage soft, free filaments or tacile processes at the tip. The ventral fins in the post-larval rockling (Fig. 12) are equally large, the distal half being black, so that at first sight the little fish when captured seems to possess a great ventral spine on each side. In the post-larval gurnard again, the huge pectoral fins form a drapery for the entire body when folded back, only the tip of the tail extending beyond them (Fig. 13). They are indeed proportionally as large as in the southern flying gurnards, but in these the fins reach full development only in adult life, while in the young stages they are comparatively small—exactly the reverse happening in the grey gurnard of our seas. The presence of the broad arches of pigment on the pectorals of several forms, such as the present species, green cod, and armed bullhead, is also an interesting feature. We have not yet read the riddle of all these changes, but in the ling the great ventral fins are probably connected with its roaming or pelagic life, and this explanation would also suit in the case of the rockling, both in their mature state seeking their food on the ground.

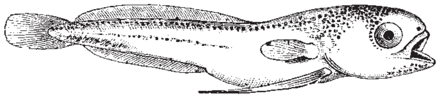

FIG. 12.—Post-larval rockling (enlarged).

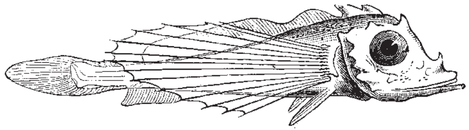

FIG. 13.—Post-larval gurnard (enlarged).

The little fishes at this stage are still more or less translucent, except in the region of the eyes, which are silvery, and on the parts where the pigment occurs. Moreover, their fondness for a minute reddish Copepod (*Calanus finmarchicus*), which occurs in myriads around them, gives the region of the stomach a faint pinkish hue from the translucency of the tissues. By and by, however, pigment appears, foreshadowing in the cod those peculiar squares which give the sides, at a somewhat later stage, their tessellated or tartan-like aspect. Besides, they are found nearer the bottom of the water, so that they can be captured in a naturalist's trawl with a fine gauze bag at the end. There is, therefore, a downward tendency as the little fishes get older and stronger, and thus in many cases a parallelism exists between them and the minute forms on which they prey, for the eggs rise on deposition toward the surface, where the helpless larvæ (or newly hatched young fishes) also often occur, and then they seek the lower regions of the water as their size increases.

There is much that is wonderful in such a life-history, especially in the metamorphoses or changes of form undergone by many of our best fishes, such as the flat fishes (Pleuronectidæ), which come out of the egg just like a haddock or cod, with an eye on each side, yet in after life have both eyes on the same side, as in Fig. 2. Nothing like this occurs in any of the higher vertebrates. Gradually during growth the body of the fish increases in depth (Fig. 14), the right or left eye passes over the ridge of the back to the opposite side (Fig. 15), while the creature, hitherto pelagic, sinks deeper in the water and exhibits a tendency to lie on the side from which the eye has passed, and which gradually loses its dark pigment so as to become white.[1] It finally reaches the bottom, taking up its residence amongst the sand or sandy mud, and lying with the two eyes and the coloured side up, the white underneath. The mode by which the eye travels round has been a fruitful source of discussion with scientific men, and amongst these the names of Steenstrup, Malm, Schiödte, and Alex. Agassiz abroad, Wyville Thomson and especially Traquair in our own country, are well known. The fact is, two methods exist in Nature: in the one the eye travels over the ridge of the head, as just described in the flounder; in the other it traverses the soft and yielding tissues of the tiny fish, and so gains the other side. In *Plagusia*, the species in which the latter remarkable change occurs in the post-larval stage, the general tissues are so transparent that the creature in a glass vessel can only be noticed by the two apparently disembodied eyes, or by the gleam of light caused by its movements; and before the change ensues in its eyes it can look obliquely through its own body and see what passes on the other side.[2]

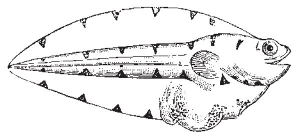

FIG. 14.—Young "witch" (*Pleuronectes cynoglossus*) in the third stage (enlarged).

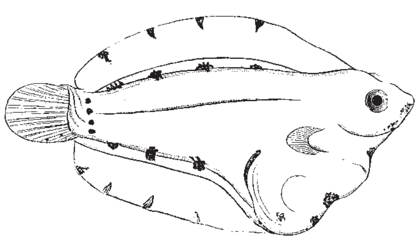

FIG. 15.—Young "witch" at a later stage, the left eye just appearing on the ridge of the head (enlarged).

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[1] The tardy disappearance of the pigment in some forms is interesting.

[2] Alex. Agassiz, Proceed. Americ. Acad. Arts. and Sci., vol. xiv. p. 8, 1878.

Up to this stage in the life-history of both round and flat fishes it will have been apparent that the efforts of man can have little effect on the vast multitudes of the eggs and minute fishes. His trawl sweeps beneath them, or they are carried harmlessly through its meshes. Not even in the case of a trawl blocked by a fish-basket and several large skate are any likely to occur. No example, indeed, was procured in the trawling expeditions for the Commission under Lord Dalhousie. The hooks of the liners are too large for the mouth at this stage, and hence they escape capture. Their small size and translucency also seem to afford protection in the case of predatory fishes of their own or other kinds, for they are rare, so far as present observation goes, in the stomach of any fish. Their great numbers are doubtless kept in check by some means, and we know that even jelly-fishes (*e.g. Pleurobrachiæ*) are very fond of post-larval fishes. It is only when they become somewhat larger that they are preyed on by their own and other species, and are swept up in thousands by the destructive shrimp-nets on our sandy shores.

While the little food-fishes are assuming the change of hue indicated in the preceding pages, they in many cases seek the inshore waters; at least systematic use of the mid-water and other nets proves that at certain seasons they are met with in large numbers at the entrance to bays or off-shore, and that a little later, in the case of the cod from the 1st of June onward, they are visible from the rocky margins. The coloration in this species (cod) is now beautifully tessellated, and they swim in groups, often in company with the young green cod, at the margin of the rocks at low water, and in the little tidal bays connected with rock-pools. The latter are often richly clothed with tangles, bladder-weed, red and green seaweeds, and the green *Ulva*, amidst the mazes of which the young fishes find both food and shelter, capturing the little Crustaceans (Copepods, Ostracods, and others) swimming there, and snatching the young mussels and minute univalve mollusks from the blades of the seaweeds. To the zoologist few sights are more interesting than to watch the little cod in these fairy lakes, as they swim in shoals against the current, balancing themselves gracefully in the various eddies by aid of their pectoral fins. In a mixed company, the young cod are easily recognized by their coloration, and the reddish hue of the occiput, for the blood-vessels there shine through the tissues, which generally are more translucent than in the green cod.

Prof. G. O. Sars considered that about this stage there was an intimate connection between them and the hordes of Medusæ (*Aurelia* and *Cyanea*) which abound in the inshore waters towards the end of summer. He thought the young cod approached the Medusa for the sake of the minute pelagic animals stupefied by its poisonous threads, and that the fish repaid this favour by picking off a parasitic Crustacean (*Hyperia medusarum*) which clings to the Medusa. Observations, continued for a long period in this country, show however that this connection is only casual and of very little importance, and that certain *Hyperiæ* are occasionally found in vast numbers in a free condition.

As the season advances, the young cod are joined off the rocky ledges by a few pollack and whiting, but not by the haddock, which appears to have certain social views of its own—keeping probably a little farther out. The size of this cod late in autumn, as in October, varies, some reaching 4 to 5 inches in length. Their food ranges from zoophytes to crustaceans, mollusks, and small fishes, and in confinement the larger are voracious, an example about 5 inches readily attacking a smaller (3 inches), and swallowing it as far as possible, though for some time a considerable portion of the body and tail of the prey projected from the mouth. Moreover, the tessellated condition becomes less marked, and as they approach 8 inches in length a tendency in some to uniformity of tint is noticeable. Many of those, however, that continue to haunt the rocky shores and the tangle-forests beyond low water still retain for some time mottled sides, and they are known by the name of rock-cod. Further, while their growth in the earlier stages is less marked, it is now very rapid—even in confinement. The exact rate of growth in the free condition in the sea is difficult to estimate, but the little cod of an inch and a half to an inch and three-quarters in June reach lengths varying from 3 to 5 inches in autumn, and in the tanks of the laboratory, specimens 5 inches in August attain 8 inches the following March. At Arendal, in Norway, where opportunities for watching the growth of cod in confinement have been supplied with a liberality yet foreign to our country, Dannevig found that the cod of 3 mm. in April reached only 15 mm. in June, a length somewhat at variance with the condition as above stated on our shores. In July they measured 2 inches, in September 3½ inches, and in October about 4½ inches. The second year they attained 14 to 16 inches in length. In artificial circumstances, as well as in nature, it is found that great variation exists in the sizes of the young fishes of the same age, and this variation would not seem to be related to temperature.

At the stages just mentioned they now come under the notice of both liner and trawler, for young cod 5 or 6 inches in length occasionally take a haddock-hook, and those somewhat larger (9 to 18 inches) occur in certain hauls of the trawl, especially off a rocky coast like that of Aberdeenshire, south of Girdleness, as well as on the hooks of the liners on rough ground. Special trips, indeed, were, and perhaps are, made by the liners for the capture of these young cod (termed codling), and thus their numbers are kept in check.

So far as present observations go, therefore, the young cod in a free condition reach the length of from 4 to 10 inches the first year, while in the second they attain from 10 to 20 inches or more. It probably takes 3 or 4 years (and this is the original opinion of Sars) or more, to reach full maturity, and a length of 3 feet or upwards; though he mentions having seen young cod a foot in length, with mature roe and milt in the fish-market of Christiania. These, however, were probably abnormal examples.

Let us now glance at the condition in the whiting. Its earlier post-larval stages immediately following those observed in the tanks at the laboratory (for we failed to rear them) are even now somewhat obscure, but they probably approach those of allied forms such as the cod and haddock. The characteristic nature of the larval pigment, however, would lead to the belief that perhaps in the brighter tints (*e.g.* yellow), differences may occur. Such, however, are lost before they come under observation; for all these delicate and minute forms are dead before reaching the deck, and indeed considerably altered. The pressure to which they are subjected in the large mid-water net by the crowds of Hydromedusæ and Ctenophores alone would suffice for this, and the handling of the heavily laden net increases the dangers to forms so fragile. One about 12 mm. shows in spirit the dorsal and anal fins outlined though not separated from each other, and permanent rays occur in them and in the caudal. Minute ventrals are present, while the pectorals form large mobile fans. Groups of black pigment-corpuscles are distributed along the base of the dorsal and anal fins and over the brain, and a similar series occurs along the ventral median line of the abdomen. The sides have these blackish pigment-corpuscles more generally distributed than in the cod. No barbel is noticeable. When a little longer (15 mm.), the species is distinguished from the young cod by a more abundant distribution of black pigment-specks along the sides of the body and on the fins, and by the greater length and diminished depth of the first anal fin. The median line of pigment still runs along the ventral surface of the abdomen. At 20 mm. the characters that distinguish it from the cod of the same size are better marked, viz. the distribution of dense blackish pigment along the base of the dorsal fins; and it soon spreads downward over the sides. The first anal fin assumes the character of the adult, and a minute papilla indicates a barbel. Between the stage just mentioned and a length of 28 mm. a decided change in the dense dorsal pigment takes place, viz. a tendency to form separate groups or touches (Fig. 16). These differ from the cod in being confined to the dorsal region, though a few bars occur at the base of the tail. The fish is also now minutely flecked, all over the head, sides, snout, and fins with black pigment, and its general outline approaches that of the adult. It is at once distinguished from the young cod by the shortness of the snout, irrespective of the features already pointed out, by the coloration, and by the shape of the first anal fin.

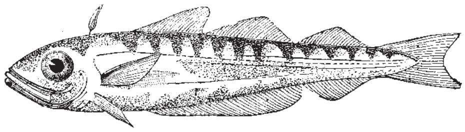

FIG. 16.—Young whiting, with serrated dorsal pigment-band and parasitic *Chalimus*.

The differentiation of the two species, viz. the cod and the whiting, is very marked in spirit at the length of 34 mm. In the whiting the median dorsal fin is less abruptly elevated than in the cod, and the first anals diverge widely, the elongation of the latter being probably connected with the abbreviation of the abdomen. The body of the whiting is more plump and neatly rounded than in the cod, which is flatter and has generally a more prominent abdomen. The pigment-specks closely cover the sides of the body in the whiting, as well as the membranous webs of the dorsal fins, and are continued on the head. The pigment at the base of the caudal rays is more distinct in the whiting, and the lancet-like caudal termination of the body is longer in this species. The myotomes are coarser in the cod, and the surface has little of the dappled silvery sheen of the whiting. The chromatophores are larger in the cod, and are grouped in blotches over the surface, with intermediate pale patches, and the shoulder and head have much less pigment than in the whiting. Both the pectoral and ventral fins of the cod are shorter than those of the whiting. The snout in the latter is shorter and broader as well as deeper, and the short sub-mental papilla is in contrast with the long barbel of the cod of the same length. The whiting, produced from an egg of larger size, would appear to attain a plump body and finished outline sooner than the cod.

The foregoing stages are very abundant in autumn in the deep water off the Isle of May and the mouth of the Forth, but they also appear west of Inchkeith in the latter estuary. They are indeed more characteristic of the former region, as far as present observations go, than of the shallow water of the open bays, such as St. Andrews, though on reaching a somewhat larger size they are quite common in the latter expanse. Both they and the cod in these early stages are infested by a Crustacean parasite (*Chalimus*), which adheres to various parts of the head and body, just as the larval *Anceus* tenaciously attacks the young flounders in tidal harbours and inshore grounds.

The young whiting at a later stage (3 to 5 inches) joins the young cod at the margins of the rocks, and forms independent shoals in tidal harbours, as well as occurs some distance off shore, being frequently got in the mid-water net in the deeper water. Towards the latter size (6 to 7 inches) it readily takes the hooks of the liner, and in certain bays the multitudes of young whiting prove an inconvenience to the fishermen. As it increases in size great shoals are formed in the offing, though a few small are almost always found in inshore waters.

The young round fishes, such as cod, haddock, and whiting, of similar or nearly similar size, seem respectively to herd together. Thus it happens that in certain hauls of both liners and trawlers the majority agree in size. This is well known to the liners, who in former days specially sought out the young cod as already indicated. The same feature is observed in many other fishes, and probably conduces to their safety.

So far as known, the adult fishes of the three kinds specially alluded to in the preceding paragraph (viz. cod, haddock, and whiting) follow no very definite law in regard to migrations, if we except the apparent congregation in certain regions during the spawning season, as pointed out, for instance, by Sars, off Lofoten, where they occur in vast numbers from January to March. In our own country, again, the appearance of shoals of haddocks and whiting in certain localities is another example. How far such multitudes, however, are influenced by the abundance of food is still an open question. In British seas the herring is the main cause of these congregations in the cod and haddock; the former chiefly pursuing the fishes, the latter their eggs. In the same way, the abundance of Norway lobsters and similar food on the grounds called banks exercise considerable influence on the presence of cod.

It has already been pointed out, however, that in their young stages certain migrations do occur. Thus the post-larval cod by and by seeks the Laminarian region, while the older forms for the most part tend to go seaward. The same occurs even in a more pronounced manner with the ling, the adults of which as a rule are found in deep water. The pelagic post-larval ling seeks downwards as it grows, and is seldom found near the shore till it attains the length of 6 or 7 inches—in short, until it is barred with pigment. As it increases in size it migrates seaward. Similar features are noticed in the plaice. As observed in the trawling expeditions of 1884, only large plaice as a rule are procured in deep water off the east coast, while the sandy bays abound with those ranging from 11 inches downward, and none of the females of which appear to be mature. Multitudes of little plaice haunt the margins of these sandy beaches, but it cannot be said that forms which have the length, for example, of 3 inches, are confined to any particular line drawn across a bay, for small forms (2 to 4 inches) occur in hauls all over such a bay as that of St. Andrews. Small turbot and halibut in the same way are often found in the shallow bays, while the large adults are inhabitants of the deeper water. Such would not, however, seem to be the case with certain skate, very large adults of which occur in the shallow water of the sandy voes in Shetland.

On the other hand, the witch (*Pleuronectes cynoglossus*) keeps to its special areas, both as regards the young and the adult condition, so that the movements of eggs, larval and post-larval forms are circumscribed; and the same would seem to be the case with the topknot (*Zeugopterus*) and sail-fluke (*Arnoglossus*). The dab (*Pleuronectes limanda*), again, is found in all stages both in comparatively deep and comparatively shallow water.

Almost all our valuable food-fishes, therefore, are produced from minute pelagic eggs, the enormous numbers of which provide for a vast increase and wide distribution of the species; yet it cannot be said that this habit alone provides for their multiplication when the case of the herring with its demersal eggs, fixed firmly to the bottom, is considered. It has to be borne in mind, however, that the larval herring immediately mounts upward toward the surface as soon as its strength suffices.

Many striking changes occur during growth, both in external form and coloration, but it is difficult at present to lay down any general law that would apply to all cases, though those in which certain migrations take place during growth show such changes very prominently. The young round fishes by and by roam about the sea in shoals, led hither and thither mainly by the presence of food; though in the case of the larger and adult forms, safety or freedom from molestation may have some influence. Though so minute on escaping from the egg, their growth is, by and by, rapid, and the duration of life in such as the cod is considerable. Abundance of food, more than any special instinct, would appear to be the main cause of their migrations in the adult or semi-adult state, and that food is as varied as their haunts; in short, it embraces every sub-kingdom up to their own, for fishes and their eggs form a large share of their diet.

There would be little difficulty in adding to the sea great numbers of larval forms of any species of which eggs can be procured: yet if a few adults can be obtained in such waters at the proper season it is still an open question whether the natural process with its surroundings would not be more successful.

In the foregoing remarks I have but touched on a few of the leading features of the life-history of a food-fish; for the subject is one of vast extent, and some of the points embraced in it are by no means easily solved. We have only earnestly entered on the study of the subject in this country within the last few years, and much yet remains to be done, even in some of the most common marine fishes. However, the zoological investigator is here stimulated by the fact that all his labours directly bear on the public welfare, for it need hardly be pointed out that a thorough knowledge of the development and life-histories of our food-fishes is the first step to sound legislation and effective administration. The State has in past years spent princely sums on more or less pure science, as in the memorable voyage of the *Challenger*. There can be no doubt that at the present moment the public interests demand a searching and long-continued inquiry nearer home, viz. the exhaustive investigation of all that pertains to the food-fishes of our shores, since the problems connected therewith affect the prosperity of so large a portion of the population.

ON THE MENTAL FACULTIES OF ANTHROPOPITHECUS CALVUS.[1]

THE female Chimpanzee which has now been in the Society's Menagerie for nearly six years has attracted general notice, not only on account of her peculiar zoological characters, but perhaps still more on account of her high intelligence. This is conspicuously displayed by the remarkable degree in which she is able to understand the meaning of spoken language—a degree which is fully equal to that presented by an infant a few months before emerging from infancy, and therefore higher than that which is presented by any other brute, so far, at least, as I have met with any evidence to show. Nevertheless, the only attempts that she makes by way of vocal response are three peculiar grunting noises—one indicative of assent or affirmation, another (very closely resembling the first) of dissent or negation, and the third (quite different from the other two) of thanks or recognition of favours. In disposition she is somewhat capricious, though on the whole good-humoured, fond of her keepers, and apparently never tired of a kind of bantering play which off and on they keep up with her continually. By vocalizing in a peculiar monotone (imitative of the beginning of her own "song"), they are usually able to excite her into the performance of a remarkable series of actions. First, she shoots out her lips into the well-known tubular form (depicted in Darwin's "Expression of the Emotions," p. 141), while at the same time she sings a strange howling note interrupted at regular intervals; these, however, rapidly become shorter and shorter, while the vocalization becomes louder and louder, winding up to a climax of shrieks and yells, often accompanied with a drumming of the hind feet and a vigorous shaking of the network which constitutes her cage. The whole performance ends with a few grunts.

A year or two ago it occurred to me that I might try some psychological experiments on the intelligence of this animal. The circumstances in which she is placed, however, did not prove favourable for anything like systematic instruction. Being constantly exposed to the gaze of a number of people coming and going, and having her attention easily distracted by them, the ape was practically available for purposes of tuition only during the early hours of the morning, before the Menagerie is open to the public; and, as a rule, I did not find it convenient to attend at that time. Therefore, the results which I am about to describe do not in my opinion represent what might fairly have been expected under more favourable conditions: if the Chimpanzee could have been kept as a domestic pet for a few months (as I kept the Cebus kindly lent me for the purposes of psychological observation by this Society), there can be no doubt that many much more interesting results might have been obtained. Nevertheless, it appears to me that even those which thus far have been obtained are worthy of being placed on record; and although some of them have already been published a few months ago in my work on "Mental Evolution in Man," since that time some further progress has been made; and therefore in the present paper I will state together all the facts which have been hitherto observed.

Having enlisted the intelligent co-operation of the keepers, I requested them to ask the ape repeatedly for one straw, two straws, or three straws. These she was to pick up and hand out from among the litter in her cage. No constant order was to be observed in making these requests, but, whenever she handed a number not asked for, her offer was refused, while, if she gave the proper number, her offer was accepted, and she received a piece of fruit as payment. In this way the ape was eventually taught to associate these three numbers with their names. Lastly, if two straws or three straws were demanded, she was taught to hold one straw or two straws in her mouth until she had picked up the remaining straw, and then to hand the two straws or the three straws together. This prevented any possible error arising from her interpretation of vocal tones—an error which might well have arisen if each straw had been asked for separately.

As soon as the animal understood what was required, and had learnt to associate these three numbers with their names, she never failed to give the number of straws asked for. Her education was then extended in a similar manner from three to four, and from four to five. Here, for reasons to be presently stated, I allowed her education to terminate. But more recently one of the keepers has endeavoured to advance her instruction as far as ten. The result, however, is what might have been anticipated. Although she very rarely makes any mistake in handing out one, two, three, four, or five straws, according to the number asked for; and although she is usually accurate in handing out as many as six or seven; when the numbers eight, nine, or ten are named, the result becomes more and more uncertain, so as to be suggestive of guess-work. It is evident, however, that she understands the words seven, eight, nine, and ten to betoken numbers higher than those below them; for if she is asked for any of these numbers (*i.e.* above six), she always gives some number that is above six and not more than ten; but there is no such constant accuracy displayed in handing out the exact number named as is the case below six. On the whole, then, while there is no doubt that this animal can accurately compute any number of straws up

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[1] Paper read before the Zoological Society on June 4, 1889, by Prof. George J. Romanes, F.R.S.